Updated and downscaled European Winter Hardiness Zone maps including Urban Heat Island effects for urban tree species selection.

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Background

One of the criteria for selecting tree species in urban environments to maximise the positive effect of ecosystem sevices like shade and evapotranspirative cooling is Winter Hardiness. Accurate Winter Hardiness Zone (WHZ) maps are vital for matching tree species with area.
Here we present updated and downscaled maps for Winter Hardiness Zones. These maps allow for tree species selection on a sub-city scale.

WHZ maps, past and present

- Winter Hardiness is represented by the yearly average lowest minimum temperature present in an area (TN_N) (Daly et al., 2012).
- Areas with similar winter hardiness are grouped into Winter Hardiness Zones (WHZ).
- Data on minimum temperature (TN) was gathered from E-OBS (Cornes et al, 2018)

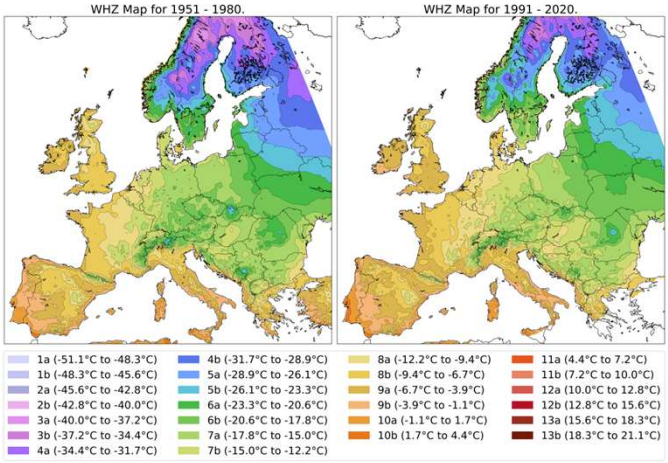

Figure 1. The European WHZ maps for 1951-1980 (left) and 1991-2020 (right). This shows the lowest daily minimum 2m air temperature of the year, averaged over 30 years. WHZ calculation methods and classification definitions are taken from Daly (2012) and made using E-OBS V.26 data.

Urban scale WHZ maps

Development

- We combined urban morphological parameters (obtained from Local Climate Zones) and (urban) meteorological data to develop a model for urban minimum temperatures, significantly improving urban TN_N prediction compared to using just rural data.

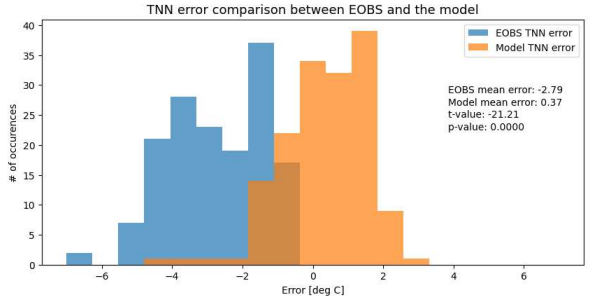

Figure 2. Histogram of the frequency of error values of the urban TN_N estimates without the model (E-OBS background data) and with the model using the TN_N values of all Amsterdam urban observation sites between 2015 and 2022. $p = 3*10^{-62}$

Urban Scale WHZ maps

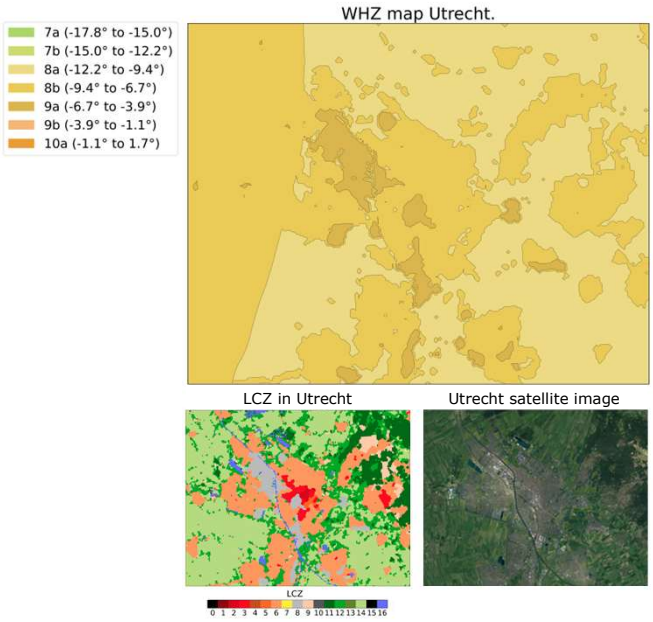

Figure 3. Three maps of Utrecht, a city in the Netherlands with ~450.000 inhabitants. Top: WHZ map of Utrecht with a 100x100m resolution, developed by this study, showcasing how these maps allow for reading WHZ at a sub-city scale. Bottom left: LCZ of Utrecht with a 100x100m resolution. Bottom right: Satellite image of Utrecht, from Google Maps.

Case Study: Future of the Netherlands

- Royal Netherlands Meteorological Institute climate scenario's for the Netherlands (van den Hurk, 2014).

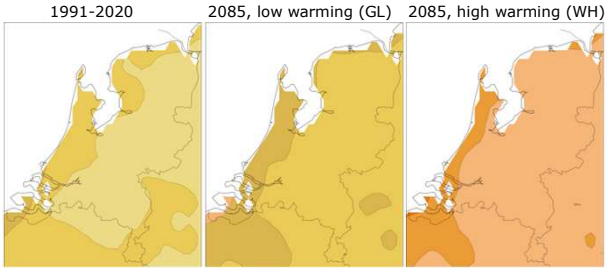

Figure 4. Three WHZ maps of the Netherlands. Left: the current WHZ map, a subsection of figure 1 (right). Middle: the WHZ map for the Netherlands in 2085 according to the GL scenario, assuming 1,5°C warming and little change in the global circulations. Right, the WHZ map for the Netherlands in 2085 according to the WH scenario, assuming 3,5°C warming and large changes in the global circulation.

Conclusion

Winter hardiness zones have substantially shifted over Europe, reflecting warmer winters. Cities have a different hardiness than the surrounding area, and our method helps in modelling this. These new maps can prove to be useful tools in selecting tree species for urban environments.

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